Final Exam Review Sheet
Honors Physics

1. Kinematics:
   a. Motion graphs:
      i. Displacement v. time.
      ii. Velocity v. time.
      iii. Acceleration v. time.
      iv. Relationship between the three types of motion graphs.
   b. One-Dimension:
      i. Variables (units): Time (seconds: s), displacement (meters: m), initial velocity (meters per second: m/s), final velocity (m/s), acceleration (meters per second squared: m/s/s).
      ii. Equations.
      iii. Free-fall.
   c. Two-Dimensions:
      i. Same variables as One-Dimension, except in both the x- and y-directions.
      ii. Vectors:
         1. Head-to-tail addition method.
         2. Components addition method.
         3. Sine-cosine-tangent to break vector into components (triangles!).
      iii. Projectile Motion:
         1. No acceleration in x-direction.
         2. Free-fall in y-direction.
         3. Use multiple kinematics equations to find required variable(s).
         4. Break velocities into triangles to find initial or final x- and y-velocities.

2. Forces:
   a. Newton's Laws:
      i. Object in motion/at rest stays in motion/at rest unless acted upon by outside force.
      ii. Net force equals mass times the acceleration.
      iii. When one body exerts a force on a second body, the second body exerts an equal and opposite force on the first body.
   b. Variables (units): Force (Newtons: N; kg*m/s/s), mass (kg), acceleration (m/s/s).
   c. Types of forces:
      i. Applied
      ii. Friction
      iii. Weight
      iv. Tension
      v. Drag
      vi. Normal
   d. Free-body diagrams:
      i. Draw forces perpendicular to each other (break down into components if force is at an angle).
      ii. Draw all forces acting on body, unless told to ignore a certain force.
      iii. Arrows are needed to give direction of forces.

        iv. Lengths of arrows should be approximately equal to magnitude of forces. If the magnitude of the forces is unknown, then simply draw an arrow of some length.
    e. Weight:
        i. Acceleration is acceleration due to gravity: 9.8 m/s/s.
        ii. Always in the downward direction (on Earth).
    f. Friction:
        i. Coefficient of friction is the measure of how difficult it is to drag one object across another object. It has no units.
        ii. Calculated by: Force of friction = (coefficient of friction)(normal force).
    g. Normal:
        i. Always perpendicular to a surface.
        ii. Must have a surface to have a normal force.
    h. Important information:
        i. Direction of net force and acceleration is the same.
        ii. In many problems, the forces in the x- and y-directions may be analyzed independently, and then combined through another force equation or a triangle.
        iii. Friction and drag act in the direction opposite the motion of the object, parallel to the surface on which the object is moving.

3. Momentum:
    a. Single-Object Momentum:
        i. Variables (units): Momentum (kg*m/s), mass (kg), velocity (m/s).
        ii. Equation.
    b. Impulse-Momentum Theorem:
        i. Variables (units): Force (N), change in time (s), momentum (kg*m/s), mass (kg), change in velocity (m/s).
        ii. Impulse is defined as force times the change in time.
        iii. Equation.
    c. Conservation of Momentum:
        i. Initial momentum is equal to the final momentum.
        ii. More interesting if there is more than one object, so both initial momenta are added together and both final momenta are added together.
        iii. Equation.
    d. Collisions:
        i. (Perfectly) Elastic:
            1. Hit and bounce; think billiard balls.
            2. Objects stay separate, so four terms in expanded equation.
            3. Momentum and kinetic energy conserved.
            4. Equation.
        ii. (Perfectly) Inelastic:
            1. Hit and stick; think two pieces of putty.
            2. Masses combine in final case, so just one final velocity. Three terms in expanded equation.
            3. Momentum conserved, kinetic energy is NOT conserved.
            4. Equation.
        iii. In real world, no collision is ever perfectly elastic or inelastic.

4. Work, Energy, Power:
    a. Work:
        i. Variables (units): Work (Joules: J; kg*m*m/s/s), force (N; kg*m/s/s), displacement (m), theta (degrees).
        ii. Force must have some component that is in the same direction as displacement, otherwise it is not scientific work.
        iii. Equation.
    b. Kinetic Energy:
        i. The energy of movement.
        ii. Variables (units): Kinetic energy (J), mass (kg), velocity (m/s).
        iii. Equation.
    c. Gravitational Potential Energy:
        i. Related to the height above a set zero point.
        ii. We choose where the zero point is (make a convenient choice).
        iii. Variables (units): Potential energy (J), mass (kg), acceleration due to gravity (m/s/s), height (m).
        iv. Equation.
    d. Work-Energy Theorem:
        i. Work is equal to the change in energy. Work being done *on* an object increases energy; work being done *by* an object decreases energy.
        ii. Simple equation to begin with, but it becomes rather complicated when the kinetic and potential energies are included.
        iii. Work may be done by non-conservative forces on a system, changing the energy of the system.
        iv. Equation.
    e. Conservation of Energy:
        i. Energy is conserved if we ignore non-conservative forces (friction, drag, applied).
        ii. Initial energy is equal to final energy.
        iii. Simple equation to begin with, but it becomes rather complicated when the kinetic and potential (both gravitational and spring) energies are included.
        iv. Equation.
    f. Power:
        i. Rate of work done on or by an object or system.
        ii. Variables (units): Power (Watts: W; J/s), work (J), time (s).
        iii. Equation.

- g. Energy Transformations:
  - i. Types of Energy:
    1. Chemical.
    2. Electromagnetic: light, electricity, magnetism.
    3. Mechanical.
    4. Nuclear.
    5. Thermal.
  - ii. Energy is transferred from one object to another, and it may change forms as it is passed. Energy is also lost when it is passed through objects, mostly to heat and sound.
- h. Simple Machines:
  - i. Ideal machine is 100% efficient, meaning all energy input is changed into work that the machine may do.
  - ii. No real-world machine may have 100% efficiency, meaning some energy is lost. Common losses are to heat and sound.
  - iii. Machines change either the amount of force needed to do work or the distance over which the work is done; how much they change the amount of work is called the mechanical advantage.
  - iv. Simple machines studied: Levers, inclined plane, wheel and axle, pulley.

5. Electrostatics and Circuits:
- a. Electrostatics:
  - i. Properties of Charge:
    1. Two kinds
    2. Electric charge is conserved
    3. Electric charge is quantized
  - ii. Transfer of Charge:
    1. Contact
    2. Induction
  - iii. Coulomb's Law:
    1. Equation
    2. Variables: Electric force (F, units: Newtons [N]), charges (q, units: Coulombs [C]), distance (r, units: Meters [m])
    3. Sign comes from attraction or repulsion of two charges being analyzed
    4. Electric force is a field force
  - iv. Electric Field:
    1. Definition
    2. Strength depends on change and distance
    3. Equation of electric field due to a point charge using a test charge
    4. Variables: Electric field strength (E, units: Newtons per Coulomb [N/C]), charge, distance
    5. Sign comes from attraction or repulsion of two charges being analyzed
    6. Electric field lines
       - a. Rules for drawing
       - b. Proportional to amount of charge

v. Electrical Potential Energy:
  1. We only consider the case of a uniform electric field
  2. Equation
  3. Variables: Electric potential energy (EPE, units: Joules [J]), charge, electric field, distance (d, units: Meters [m])
  4. Charge must move in the direction of the electric field for electric potential energy to change

vi. Potential Difference (also called Electric Potential; I will use them interchangeably):
  1. Equation for potential difference between two charges
  2. Variables: Electric potential (ΔV, units: Volts [V]), electric potential energy, charge
  3. Equation for potential difference in a uniform electric field
  4. Variables: Electric potential, electric field, displacement (d, units: Meters [m])
  5. Equation for potential difference between a point at infinity and a point near a point charge
  6. Variables: Electric potential, charge, distance

vii. Current and Resistance:
  1. Definition of electric current
  2. Equation
  3. Variables: Electric current (I, units: Amperes [A]), charge passing through given area (ΔQ, units: Coulombs [C]), time interval (Δt, units: Seconds [s])
  4. Flow of electrons versus conventional current
  5. Definition of resistance
  6. Equation
  7. Variables: Resistance (R, units: Ohms [Ω]), electric potential, current
  8. Resistance depends on length, cross-sectional area, material, and temperature
  9. Ohm's law definition and equation

viii. Electric Power:
  1. Definition
  2. Equation
  3. Variables: Electric power (P, units: Watts [W]), current, electric potential
  4. Can use Ohm's law to solve for two more equations

b. Circuits:

i. Schematic diagrams:
  1. Definition
  2. Elements that are used to symbolically represent each physical piece

ii. Electric circuits:
  1. Definition
  2. Types: Short, series, parallel

iii. Resistors in Series or Parallel
  1. Series:
     a. Each resistor carries the same amount of current
     b. Equation for equivalent resistance
     c. Voltage drop across each resistor calculated from Ohm's law
     d. If lightbulbs substituted for resistors, when one bulb goes out all bulbs go out.
  2. Parallel:

a. Each resistor has the same voltage
b. Equation for equivalent resistance
c. Only calculate equivalent resistance and total current
d. If lightbulbs substituted for resistors, when one bulb goes out all other bulbs stay lit.

3. Complex circuits:
   a. Find equivalent resistance (most will be six pieces)
   b. Start from outside and work inwards using the series and parallel equations
   c. Final circuit should just have battery and equivalent resistor
4. Kirchoff's laws:
   a. Voltage law: The sum of the voltage drops in a loop of a circuit is equal to the sum of the voltage gains.
   b. Current law: The sum of currents flowing into a junction is equal to the sum of currents flowing out of a junction.
   c. With these two laws, voltage and current for all resistors and the total circuit may be calculated.

6. Waves, Sound, and Light:
   a. Properties of Waves:
      i. Wave motion
      ii. Wave types:
         1. Sine waves describe particles exhibiting simple harmonic motion
         2. Transverse waves
         3. Longitudinal waves
         4. Equation for speed of a wave
         5. Variables: Velocity (v, units: Meters per second [m/s]), frequency (f, units: Hertz [Hz]), wavelength (λ, units: Meters [m])
      iii. Wave interactions:
         1. Interference:
            a. Constructive
            b. Destructive
         2. Reflection:
            a. Free boundary
            b. Fixed boundary
         3. Standing waves:
            a. Definition
            b. Nodes and antinodes
   b. Sound:
      i. Sound Waves:
         1. Production of sound waves
         2. Characteristics of sound waves:
            a. Frequency determines pitch
            b. Speed depends on medium
         3. Doppler Effect

ii. Sound Intensity and Resonance:
   1. Sound intensity:
      a. Definition
      b. Equation for intensity of a spherical wave
      c. Variables: Intensity (I, units: Watts per meter squared [W/m^2]), power (P, units: Watts [W]), distance from the source (r, units: Meters [m])
      d. Human hearing
      e. Decibels and sound intensity
   2. Forced vibrations and resonance:
      a. Definition of forced vibrations
      b. Definition of resonance

iii. Harmonics:
   1. Standing waves on a vibrating string:
      a. Definition of fundamental frequency
      b. Harmonic series
      c. Equation for harmonic series of standing waves on vibrating string
      d. Variables: Frequency (f_n, units: Hertz [Hz]), harmonic number (n, units: None), speed of waves on string (v, units: Meters per second [m/s]), length of vibrating string (L, units: Meters [m])
   2. Standing waves in air columns:
      a. Open/open pipe:
         i. Definition
         ii. Equation for harmonic series of a pipe that is open at both ends
         iii. Variables: Frequency (f_n, units: Hertz [Hz]), harmonic number (n, units: None), speed of waves on string (v, units: Meters per second [m/s]), length of vibrating string (L, units: Meters [m])
         iv. All harmonics exist
      b. Open/closed pipe:
         i. Definition
         ii. Equation for harmonic series of a pipe that is open at one end and closed on the other
         iii. Variables: Frequency (f_n, units: Hertz [Hz]), harmonic number (n, units: None), speed of waves on string (v, units: Meters per second [m/s]), length of vibrating string (L, units: Meters [m])
         iv. Only odd harmonics exist because of the placement of nodes and antinodes

c. Light:
   i. Characteristics of Light:
      1. Definition of light
      2. Electromagnetic spectrum
      3. Either a particle (photon) or wave (mutually perpendicular oscillating electric and magnetic fields)
      4. All waves move at the same speed: 3E8 m/s
      5. Light waves can be approximated as rays

ii. Reflection and Flat Mirrors:
   1. Reflection:
      a. Definition
      b. Types of reflection:
         i. Spectral
         ii. Diffuse
      c. Relationship between angles of incidence and reflection
   2. Flat mirrors:
      a. Use rays to trace where image will appear
      b. Height of object equal to the height of the image

iii. Curved Mirrors:
   1. Concave spherical mirrors:
      a. Ray diagrams: six cases to draw
      b. Equation for mirrors
      c. Variables: Object distance (d_o, units: Centimeters [cm]), image distance (d_i, units: Centimeters [cm]), focal length (f, units: Centimeters [cm])
      d. Equation for magnification
      e. Variables: Magnification (M, units: None), object distance, image distance, object height (h_o, units: Centimeters [cm]), image height (h_i, units: Centimeters [cm])
      f. Rules for drawing rays
   2. Convex spherical mirrors:
      a. Ray diagrams: one case to draw
      b. Same equations as concave mirrors
      c. Same rules for drawing rays as concave mirrors

iv. Polarization:
   1. Definition
   2. Created through a filter or light reflecting off a smooth surface
   3. Using a second filter at 90º eliminates polarized light

v. Refraction:
   1. Definition
   2. Index of refraction
   3. Equation to determine the angle of refracted light: Snell's law
   4. Variables: index of refraction (n, units: None), angle (θ, units: Degrees [º])